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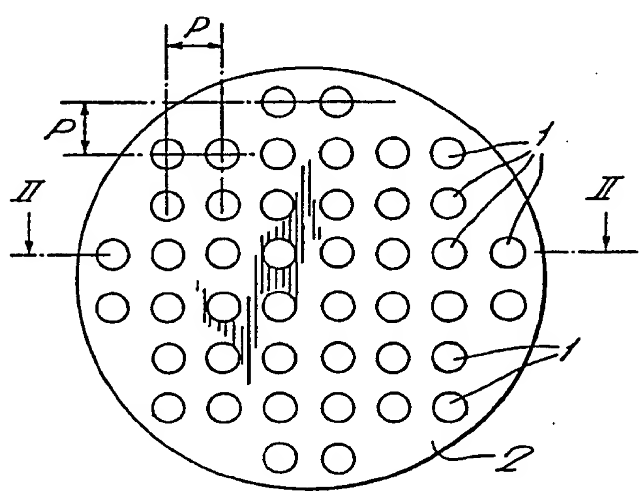
(54) Security barrier structure.

(57) An anti-drill barrier for localised protection in safe and strongroom doors comprises a closely-spaced array of cemented carbide pins 1 or balls 4 (Fig 4 not shown) force-fitted into interference holes in a steel plate 2, and aligned with the anticipated direction of attack. The force-fitting of the hard pins or balls results in a tightness of hold on these elements which not only makes them very difficult to remove from the plate but also pre-stresses them in compression, with the result that the net (tensile) stress at which they will fail under impact loading is increased. When this kind of structure is attacked with carbide-tipped drills the tendency is for the drill bit to penetrate partially into the steel surrounding the hard pins or balls whereupon the flanks of the carbide inserts on the drill tip impact the hard pins or balls and are consequently broken or ripped away from the bit.



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Security Barrier Structure

The present invention relates to a penetration-resistant barrier structure for use in the doors or walls of safes, strongrooms and the like security enclosures and seeks in particular to provide a form of construction which can be made highly resistant to attacks with drills and punches and which will be suited especially to the localised protection of the locking points or other strategically important regions within a safe or strongroom door for example.

In order to achieve drilling resistance in security enclosures it is commonplace to provide composite barrier structures including elements of a hard mineral or ceramic disposed in a cast matrix. Usually the hard elements are provided in the form of irregularly-shaped nuggets which must therefore be juxtaposed in a somewhat random fashion within the barrier, making it difficult to be sure that there is a sufficient depth of hard

material evenly distributed throughout the barrier to provide adequate resistance over the whole of the protected area. One known variation of this comprises a closely-spaced parallel array of discrete high alumina ceramic pins held in a cast aluminium alloy matrix with the longitudinal axes of the pins being arranged perpendicularly to the plane of the barrier (ie parallel to the anticipated direction of attack upon the structure), generally in accordance with the teaching in United Kingdom patent specification No 1600247. While this kind of geometrical layout of the hard elements is useful in providing a consistent degree of resistance over the protected area while minimising the volume of the expensive hard material required to protect that area, it has been found that the resistance of the known barrier structure to drilling attacks and, especially, its resistance to attacks with percussion drills, punches or the like percussive tools, is less than that which is to be desired in high security applications. This is thought to be due both to the brittle nature of the ceramic pins employed in the known structure and to the fact that a cast matrix cannot provide sufficient support for the pins to prevent failure of the pins under impact loads.

With the aim of overcoming these drawbacks of the prior art the present invention proposes a security barrier structure comprising a closely-spaced array of regularly-shaped hard elements of a cemented carbide material embedded in a supporting plate or other body, constructed by forcing the hard elements into respective members of an array of parallel bores prepared in the supporting body as an interference fit with the

respective hard elements such that those elements are securely held under compression in the body by elastic stresses set up in the body as a result of the process of forcing in the hard elements, the longitudinal axes of said bores being aligned generally perpendicularly to the plane of the barrier.

The hard elements in a structure according to the invention are preferably in the form of pins or balls of the chosen cemented carbide material. These materials, also known as "sintered carbides" and "hard metals", typically comprise compounds of tungsten carbide, titanium carbide or of both together and/or together with tantalum carbide, together with a small amount of a "cementing" metal such as cobalt or nickel. They can be made with both a sufficient hardness, say at least 1400 VPN (Vickers Pyramid Number) at room temperature, to resist the cutting action of the drills or other mechanical cutting tools which are likely to be appropriated for an attack upon the structure, and with a toughness and tensile strength (or transverse rupture strength - say at least 100,000 lb/in2 (7,000 kg/cm2) which significantly exceeds that of alumina and the like ceramic materials and which confers upon elements of cemented carbide a greater inherent resistance to destruction by percussion than the ceramics. Furthermore, and most importantly, these materials can also exhibit compressive strengths of, say, at least 400,000 lb/in2 (28,000 kg/cm2) and typically 650,000 lb/in2,(45,000 kg/cm2) which greatly exceeds that of alumina and the like and which enables the elements to be employed in the above-defined "forced-in" construction technique to which much of the improved percussion resistance of the present structure is thought to be attributable.

As has been stated, the invention proposes to construct the structure by forcing the hard elements into interference-fit bores prepared in a supporting plate or other body. With the correct choice of the body material and the degree of interference, the residual elastic stresses which are set up in the body as a result of this force fitting of the hard elements exhibit a tightness of hold on the elements such as to maximise resistance to extraction of the elements and to minimise the tendency of the elements to crack or chip under impact loads. It is also desirable from the standpoint of their own physical properties that the hard elements are left with a significant induced compressive stress after the force-fitting step - since carbides are weaker in tension than in compression the net result of the induced compression is to increase the effective minimum stress at which failure occurs. This, together with the desire to provide a relatively large degree of interference between the hard elements and the bores into which they are forced (to avoid the need for critical dimensional tolerances on the bores and elements during production) predicates a material for the supporting body which has both a high elastic limit, say at least 20,000 lb/in2 (1,500 kg/cm2), because it is to this property that the maximum elastic stresses in the body are related, and a sufficient ductility to accommodate the interference without cracking or fracture (most probably a room temperature tensile ductility in excess of 10% is required). These properties may be best and most economically provided by steel as opposed to, for example, aluminium (although the latter may still be possible in some embodiments).

Using a steel supporting body gives the further advantage of enabling the barrier to be strongly attached to the associated structure without difficulty eg by welding or other conventional fixation techniques.

The form of the hard elements themselves can also be chosen so as to maximise the desired residual and induced stresses in the body and elements after force-fitting. In the case of hard pins, therefore, which will be pressed or driven endwise into the body, it is preferred for the pins to be tapered along much or all of their length. Instead of pins, balls may be employed, which have certain advantages from the point of view of production - they will be self-locating in the bores if poured over the surface of the supporting body and may be forced in by a rolling press.

Some examples of barrier structures made in accordance with the invention are illustrated in the accompanying drawings, in which:

Figure 1 is an elevation of a first structure showing the face which is presented to the direction of attack;

Figure 2 is a section on the line II-II of Figure 1;

Figure 3 is an enlarged sectional view of part of the structure of Figure 1 during assembly.

Figure 4 is an elevation of the "attack face" of a second structure;

Figure 5 is a section on the line V-V of Figure 4;

Figure 6 is an elevation of the "attack face" of a further structure; and

Figure 7 is a section on the line VII-VII of Figure 6.

The structure illustrated in Figures 1 and 2 comprises a closely-spaced array of discrete tungsten carbide pins 1 held in a mild steel plate 2. As shown more clearly in Figure 3, each pin 1 is tapered along its length, with a shallow dome at its wider end. The pins are mounted in the plate 2 with their longitudinal axes parallel to each other and the plate will be mounted in the safe door or other structure which it is intended to protect face-on to the anticipated direction of attack and with the domed ends of the pins outwards.

To construct this barrier the plate 2 is drilled with an array of plain bores 3 (Figure 3) to define the positions for the pins 1, and with a diameter to be an interference fit with the pins. The narrower end of a pin 1 is then inserted into each bore 3 and the pins are pressed fully home as shown in Figure 2 whence they are securely retained, under a considerable compressive load, by the very high elastic stresses which are induced in the steel surrounding each bore as the tapered pins progressively penetrate the plate.

In one example, an 8mm thick plate 2 of 50mm diameter is provided with an array of 7/64" (2.8mm) bores in the pattern shown in Figure 1 and at a pitch p of 6mm. The pins 1 are 8mm long and have a nominal diameter of 2.8mm widening to 3.4mm. This form of structure is

particularly suitable for resisting carbide-tipped drills in the diameter range of 10-15mm; tests have shown that, when attacked, not only is progress through the barrier extremely slow due to the very low cutting rate which can be achieved in any event against the pins 1, but also the carbide drill tips are repeatedly destroyed so that the drill in use must be continually replaced if any progress at all is to be made. This is due to the fact that the pin geometry allows partial penetration of the drill tip into the steel plate whereupon the flanks of the carbide inserts on the drill bit impact the hard pins and are consequently broken or ripped away from the bit. This process is in contrast to experience in drilling a geometrically similar array of alumina pins in a cast aluminium matrix where it has been found that the resultant percussive effect between the drill tip and pins tends to shatter the pins rather than the drill.

The structure illustrated in Figures 4 and 5 comprises a closely-spaced array of discrete tungsten carbide balls 4 held in a mild steel plate 5. The balls are mounted in the plate so as to lie generally in one plane and the plate will be mounted in the safe door or other structure which it is intended to protect face-on to the anticipated direction of attack and with the exposed faces of the balls outwards.

To construct this barrier the plate 5 is drilled with an array of plain blind bores 6 (Figure 5) to define the positions for the balls 4, and with a diameter to be an interference fit with the balls. A ball 4 is then

located in the mouth of each bore 6 and the balls are pressed fully home as shown in Figure 5 whence they are securely retained under compressive load by the very high elastic stresses which are induced in the steel surrounding each bore as the balls progressively penetrate the plate. As with all the embodiments of the invention this process tends to maximise resistance to extraction of the forced-in carbide elements and to minimise the tendency of these elements to crack or chip under impact loads, the resultant induced compressive stress in the hard inclusions also having the net result of increasing the effective minimum (tensile) stress at which failure of the carbide material occurs.

In one example, a 6mm thick plate 2, 64mm square, is provided with an array of 4.5mm deep 4.2mm diameter bores in the pattern shown in Figure 4 and at a pitch p' of 8mm. The balls 4 have a nominal diameter of 4.37mm. This form of structure is particularly suitable for resisting carbide-tipped drills in the diameter range of 10-20mm; tests have shown that, when attacked, not only is progress through the barrier extremely slow due to the very low cutting rate which can be achieved in any event against the hard balls 4, and that the spherical surfaces of the balls tend to deflect the drill, but also the carbide drill tips are repeatedly destroyed so that the drill in use must be continually replaced if any progress at all is to be made. As before, this is due to the fact that the geometry of the barrier allows partial penetration of the drill tip into the steel plate whereupon the flanks of the carbide inserts on the drill bit impact the hard balls and are consequently broken or ripped away from the bit.

In Figures 6 and 7 there is shown a construction which offers still greater protection against drilling and percussion attacks. In this case there are two plates 5 constructed with force-fitted balls 4 each similar to the Figures 4 and 5 example, but where the two plates are welded together one behind the other with the two sets of balls mutually offset by a half pitch in both orthogonal directions of the array.

CLAIMS

1. A security barrier structure comprising a closely-spaced array of regularly-shaped hard elements (1,4) embedded in a supporting body (2,5), characterised in that the barrier is constructed by forcing elements (1,4) of a cemented carbide material into respective members of an array of parallel bores (3,6) prepared in the supporting body (2,5) as an interference fit with the respective hard elements (1,4) such that those elements (1,4) are securely held under compression in the body (2,5) by elastic stresses set up in the body (2,5) as a result of the process of forcing in the hard elements (1,4), the longitudinal axes of said bores (3,6) being aligned generally perpendicularly to the plane of the barrier.

2. A structure according to claim 1 wherein the material of said body (2,5) is stressed to its elastic limit around said hard elements (1,4).

3. A structure according to claim 1 or claim 2 wherein said hard elements are in the form of pins (1).

4. A structure according to claim 3 wherein said pins (1) are tapered in the longitudinal direction and inserted endwise into the respective bores (3) with their narrower-diameter ends leading.

5. A structure according to claim 1 or claim 2 wherein said hard elements are in the form of balls (4).

6. A structure according to any preceding claim wherein the compressive strength of said cemented carbide material exceeds 400,000 lb/in2 (28,000 kg/cm2).

7. A structure according to any preceding claim comprising two said supporting bodies (5) within which are embedded respective said hard elements (4) each in an array of equivalent pitch (P'), and said two bodies (5) are rigidly united together with one said array of hard elements (4) offset from the other by a half said pitch $(\frac{P'}{2})$.

A=2πr

Fig.1.

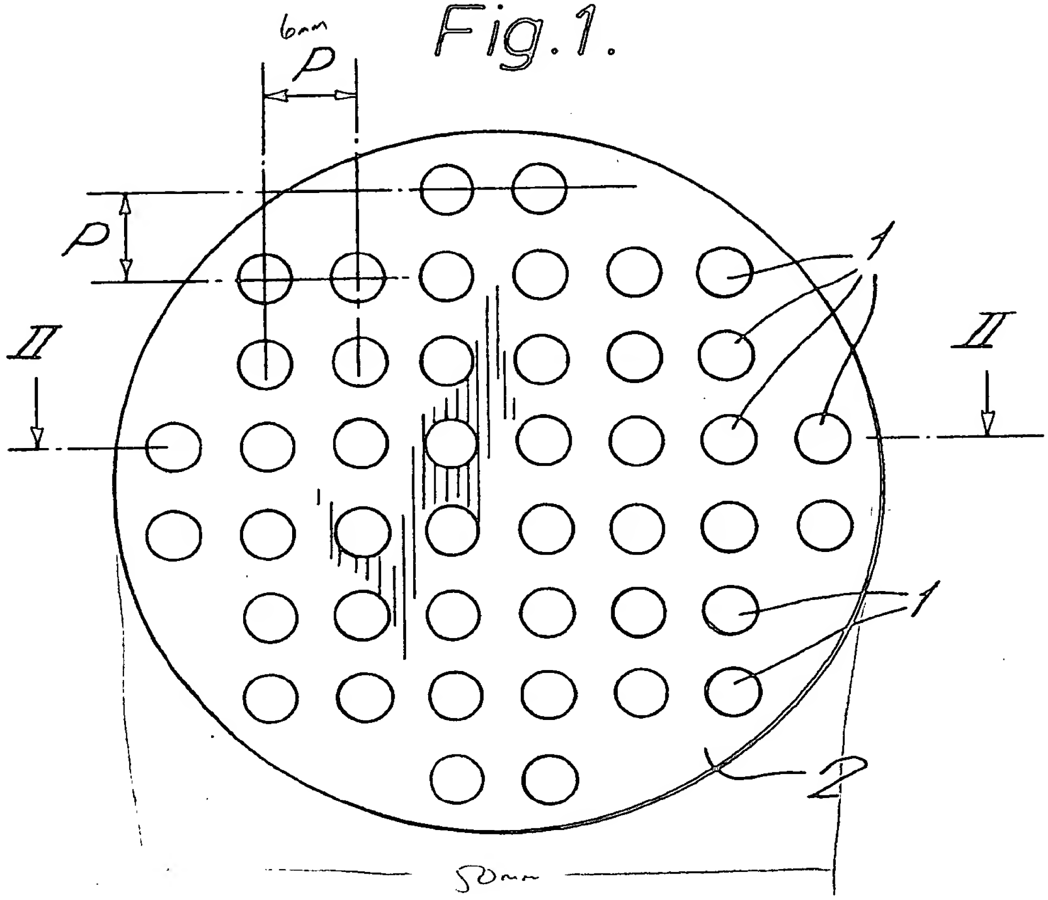


Fig.2.

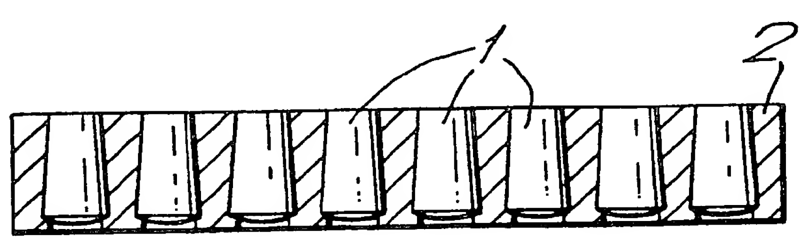
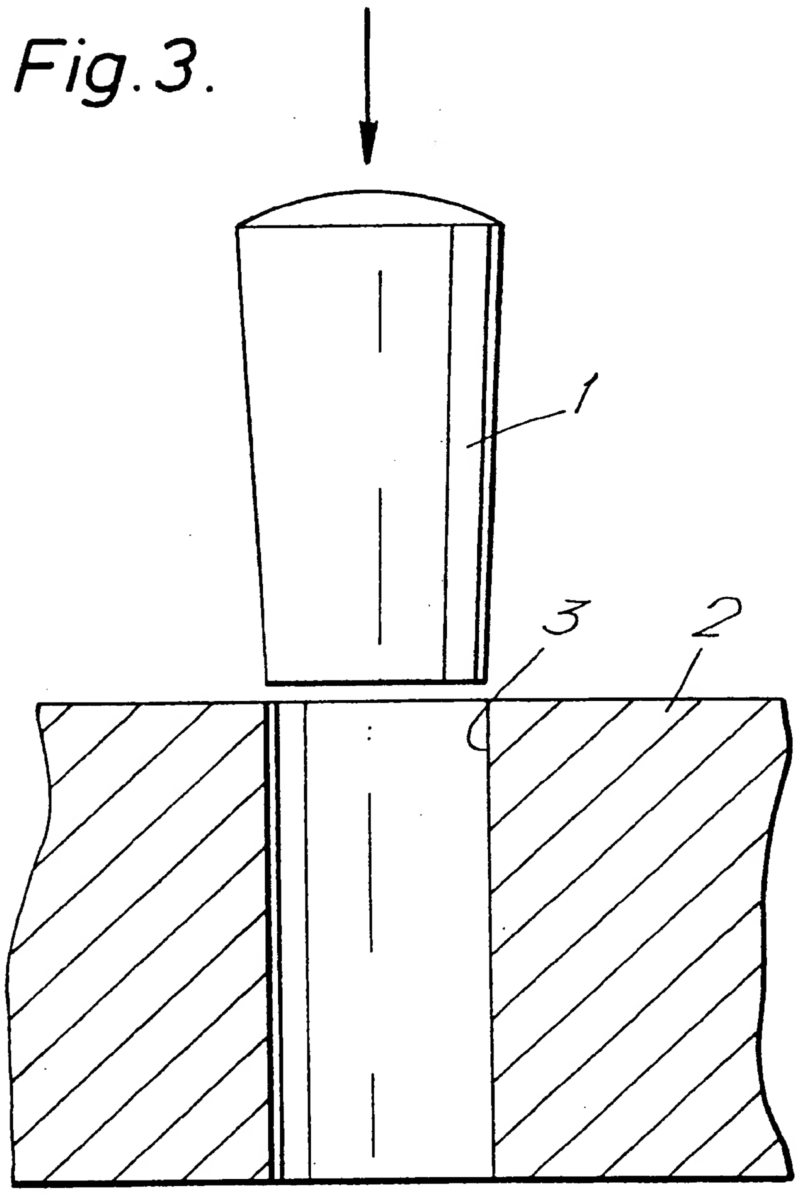


Fig. 3.



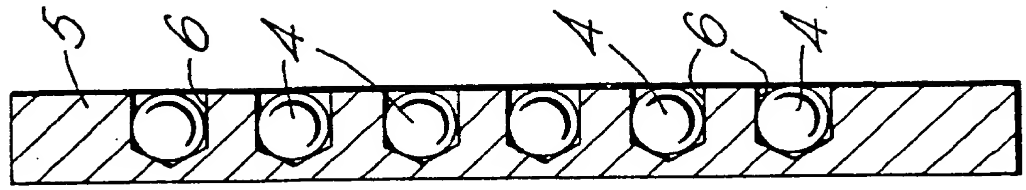


Fig.5.

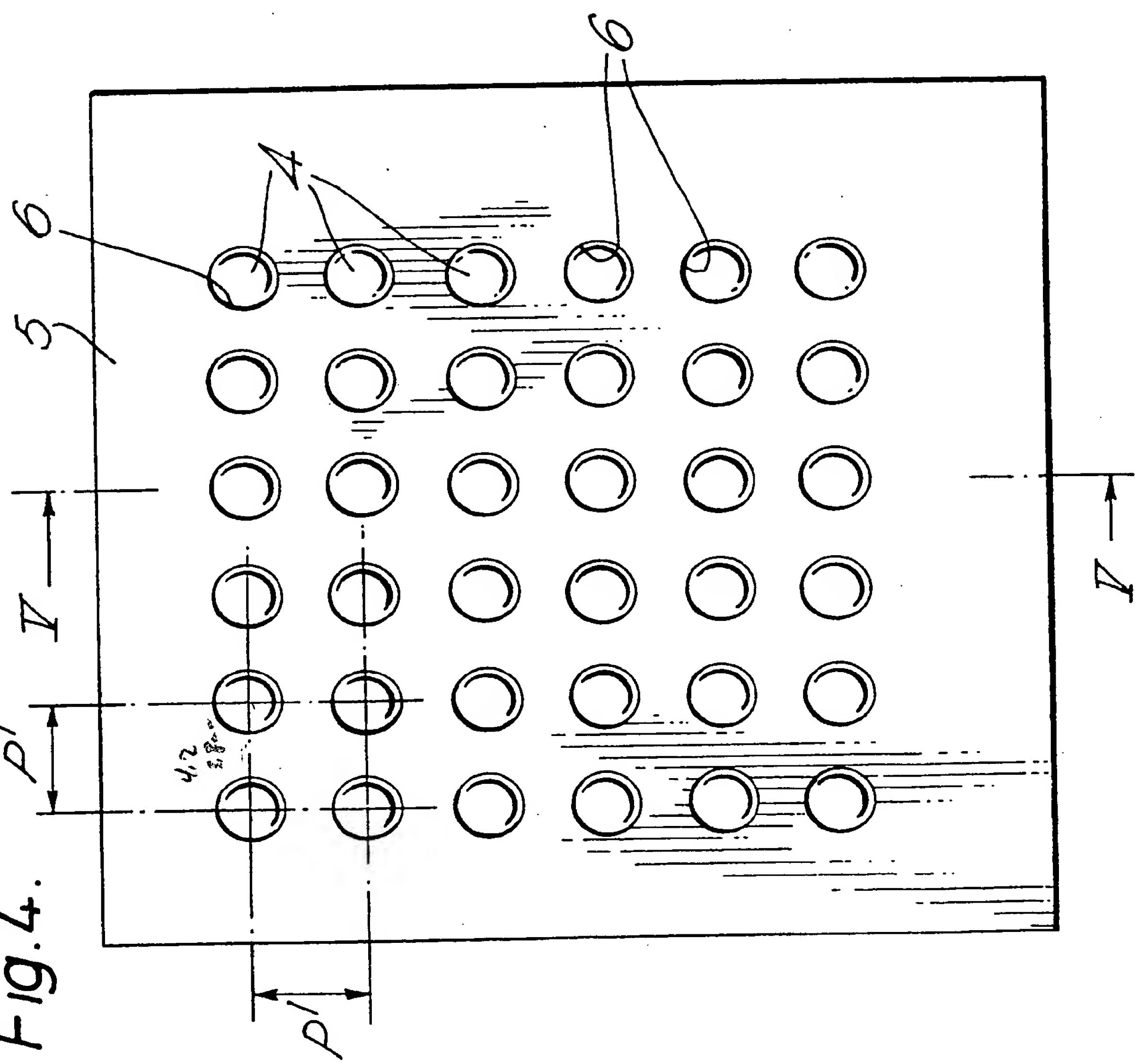


Fig.4.

Fig.7.

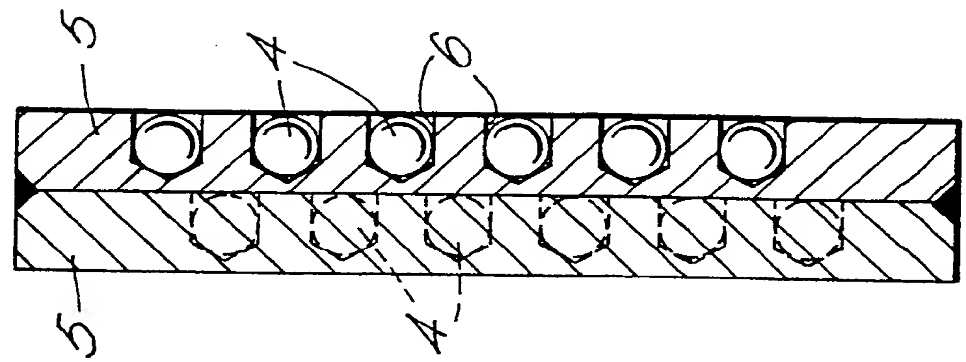


Fig.6.